
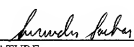


FORM PTO-1390 (Modified) (REV 10-95)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 196811US0PCT	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/623596)	
				PRIORITY DATE CLAIMED 06 March 1998	
INTERNATIONAL APPLICATION NO. PCT/JP99/01084		INTERNATIONAL FILING DATE 05 March 1999			
TITLE OF INVENTION A GENE CODING FOR PENICILLIN BINDING PROTEIN AND A METHOD FOR PRODUCING L-GLUTAMIC ACID					
APPLICANT(S) FOR DO/EO/US Masaaki WACHI, et al.					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1). 4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2)) a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)). 7. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210). 8. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. 9. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 10. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). 11. <input type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409). 12. <input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).					
Items 13 to 18 below concern document(s) or information included: 13. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 14. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 15. <input checked="" type="checkbox"/> A FIRST preliminary amendment. A SECOND or SUBSEQUENT preliminary amendment. 16. <input type="checkbox"/> A substitute specification. 17. <input type="checkbox"/> A change of power of attorney and/or address letter. 18. <input type="checkbox"/> Certificate of Mailing by Express Mail 19. <input checked="" type="checkbox"/> Other items or information:					
Request for Consideration of Documents Cited in International Search Report Notice of Priority Drawings (1 sheet) Sequence Listing (13 pages)					

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.53) 097/623596		INTERNATIONAL APPLICATION NO. PCT/JP99/01084		ATTORNEY'S DOCKET NUMBER 196811US09PCT	
20. The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) : <input checked="" type="checkbox"/> Search Report has been prepared by the EPO or JPO \$840.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) \$670.00 <input type="checkbox"/> No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) \$760.00 <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$970.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) \$96.00 ENTER APPROPRIATE BASIC FEE AMOUNT =				CALCULATIONS PTO USE ONLY	
				<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:50%; text-align: right;">\$840.00</td> <td style="width:50%;"></td> </tr> <tr> <td style="text-align: right;">\$0.00</td> <td></td> </tr> </table>	
\$840.00					
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Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)). <input type="checkbox"/> 20 <input type="checkbox"/> 30				\$0.00	
CLAIMS		NUMBER FILED		NUMBER EXTRA	
TOTAL claims		9 - 20 =		0	
Independent claims		2 - 3 =		0	
Multiple Dependent Claims (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$840.00	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). <input type="checkbox"/>				\$0.00	
SUBTOTAL =				\$840.00	
Processing fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)). <input type="checkbox"/> 20 <input type="checkbox"/> 30				\$0.00	
TOTAL NATIONAL FEE =				\$840.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL FEES ENCLOSED =				\$840.00	
				Amount to be: refunded \$	
				charged \$	
<input checked="" type="checkbox"/> A check in the amount of \$840.00 to cover the above fees is enclosed. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 15-0030 A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:					
VEUSTADT, P.C.					
 22850					
Surinder Sachar Registration No. 34,423					
 SIGNATURE Norman F. Oblon NAME 24,618 REGISTRATION NUMBER 9-5-00 DATE					

09/623596

526 Rec'd PCT/PTC 05 SEP 2000

196811US-8222-10-0 PCT

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

MASAKI WACHI ET AL :

ATTN: APPLICATION DIVISION

SERIAL NO: NEW PCT APPLICATION :
(Based on PCT/JP99/01084)

FILED: HERewith :

FOR: A GENE CODING FOR :
PENICILLIN BINDING PROTEIN
AND A METHOD FOR PRODUCING
L-GLUTAMIC ACID

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

Prior to examination on the merits, please amend the above-identified application as follows.

IN THE CLAIMS

Please amend the claims as follows:

Claim 5, lines 1-2, replace "any one of claims 1-4" with --claim 1--.

Claim 6, lines 1-2, replace "any one of claims 1-4" with --claim 1--.

REMARKS

Claims 1-9 are active in the present application. The claims are amended for clarity and to remove multiple dependencies. No new matter has been added. Applicants submit that the present application is now in condition for examination on the merits. Early notification of such is earnestly solicited.

Respectfully submitted,

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SPECIFICATION

A Gene Coding for Penicillin Binding Protein and a
Method for Producing L-Glutamic Acid

5

Technical Field

The present invention relates to a method for
producing L-glutamic acid by fermentation. L-glutamic
acid is widely used as a raw material of seasonings and
so forth.

Background Art

If coryneform bacteria are cultured in a medium
containing a restricted amount of biotin, the bacteria
produce a marked amount of L-glutamic acid. On the
other hand, if coryneform bacteria are cultured in a
medium containing an excessive amount of biotin, the
bacteria do not produce L-glutamic acid. However, it is
known that, even under such a condition, if a surface
active agent or a biotin activity suppressor such as
penicillin is added to the medium, growth of the
bacteria is suppressed and they become to produce a
marked amount of L-glutamic acid.

The glutamic acid production induced by addition
of penicillin to a medium has been studied for many

years (T.D. Nunheimer, J. Birnbaum, E.D. Ihnen and A.L. Demasin, *Appl. Microbiol.*, 20, 215-217 (1970)). The effect of penicillin is considered to cause structural change of cellular surface layers, thereby enhancing permeability of cytoplasmic membranes for glutamic acid.

In addition, it has also been studied through what kind of mechanism the restriction of the biotin amount or the addition of a surface active agent or penicillin influences the productivity of L-glutamic acid of coryneform bacteria, and presence of a gene considered to participate in the L-glutamic acid production has been elucidated (*dtsR* gene). Further, it has been confirmed that a strain of which *dtsR* gene is disrupted produces a marked amount of L-glutamic acid even under a condition in which biotin is present in such an amount that a wild strain hardly produces L-glutamic acid (International Patent Publication WO95/23224).

Furthermore, there have been obtained many findings that contradicts the explanation that the glutamic acid production is induced the enhancement of permeability of cytoplasmic membranes, and the mechanism of the glutamic acid production induced by penicillin has still been unknown (E. Kimura, Y. Kawahara and W. Nakamatsu, *Tanpakusshitu Kakusan Koso (Protein, Nucleic acid and Enzyme)*, vol. 42, pp.2633-2640 (1997)).

By the way, it is well known that penicillin binding proteins (PBPs) play an important role in

bacterial cell division. The penicillin binding proteins are considered to be enzymes that exist in bacterial cellular surface layers, and they specifically bind to β -lactam antibiotics such as penicillin.

5 Although it may vary depending on the species, it is considered that 3-8 kinds of the proteins are usually found in *Escherichia coli*, and their molecular weights are distributed around the range of 40,000-120,000. Penicillin inhibits the enzymatic reactions by binding
10 to a serine residue of an active site of the penicillin binding proteins.

It has been elucidated that 7 kinds of penicillin binding proteins exist in *Escherichia coli* (*E. coli*), which was especially a main target of researches (B.G. Spratt, *Proc. Natl. Acad. Sci. U.S.A.*, 72, 2999 (1975)).
15 Among those, those designated as PBP2 and PBP3 have been demonstrated to play an important role in cell division (B.G. Spratt, *J. Bacteriol.*, 131, 293 (1977)). However,
20 proteins exists in coryneform bacteria.

Disclosure of the Invention

The inventors of the present invention
25 investigated whether penicillin binding proteins (abbreviates as "PBPs" hereinafter) should exist also in coryneform bacteria, and analyzed their functions. As a

result, the inventors obtained a novel finding considered to be useful for elucidating the mechanism of the glutamic acid production in coryneform bacteria induced by penicillin, and at the same time, they found that the finding could be utilized for developments concerning the improvement of glutamic acid producing ability of coryneform bacteria from a viewpoint that had not been known yet.

The present invention was accomplished on the basis of the aforementioned findings, and it relates to a method for producing L-glutamic acid, comprising the steps of cultivating a coryneform bacterium in a liquid medium to produce and accumulate L-glutamic acid in the medium, and collecting the L-glutamic acid, wherein PBP does not normally function in the bacterium and the bacterium has the ability to produce L-glutamic acid

In a preferred embodiment of the present invention, the coryneform bacterium used in the aforementioned method is a bacterium in which PBP functions normally at the first temperature and does not function normally at the second temperature, and the method comprises a step of cultivating the bacterium at the first temperature to proliferate the bacterium and a step of cultivating the bacterium at the second temperature to produce L-glutamic acid.

In another embodiment of the present invention, the coryneform bacterium used in the aforementioned

method is a bacterium which harbors a plasmid containing a gene coding for PBP (PBP gene) and a temperature sensitive replication control region, and in which the PBP gene on chromosome does not function, and the plasmid can replicate at the first temperature, and cannot replicate at the second temperature.

In a further embodiment of the present invention, PBP produced by the coryneform bacterium used in the method has a temperature sensitive mutation.

In a still further embodiment of the present invention, PBP shows a molecular weight of about 60,000 in SDS-polyacrylamide gel electrophoresis, when PBP binds to penicillin G.

The second aspect of the present invention is DNA which codes for a protein defined in the following (A) or (B):

(A) a protein which has the amino acid sequence of SEQ ID NO: 2 in Sequence Listing;

(B) a protein which has an amino acid sequence of SEQ ID NO: 2 in Sequence Listing including substitution, deletion, insertion, addition or inversion of one or several amino acids, and an activity for binding to penicillin.

In a preferred embodiment of the invention, the aforementioned DNA is DNA defined in the following (a) or (b):

(a) DNA which comprises at least the nucleotide

sequence of the nucleotide numbers 881 to 2623 of SEQ ID NO: 1 in Sequence Listing;

(b) DNA which is hybridizable with a nucleotide sequence comprising at least the sequence of the nucleotide numbers 881 to 2623 of SEQ ID NO: 1 in Sequence Listing under a stringent condition, and codes for a protein having an activity for binding to penicillin.

Hereafter, the present invention will be explained in detail.

<1> PBP of coryneform bacteria

In the present invention, coryneform bacteria include those bacteria having been hitherto classified into the genus *Brevibacterium* but united into the genus *Corynebacterium* at present (*Int. J. Syst. Bacteriol.*, 41, 255 (1981)), and include bacteria belonging to the genus *Brevibacterium* closely relative to the genus *Corynebacterium*. Examples of such coryneform bacteria are listed below.

Corynebacterium acetoacidophilum

Corynebacterium acetoglutamicum

Corynebacterium callunae

Corynebacterium glutamicum

Corynebacterium lilium (*Corynebacterium glutamicum*)

Corynebacterium melassecola

- Brevibacterium divaricatum*
(*Corynebacterium glutamicum*)
- Brevibacterium flavum* (*Corynebacterium glutamicum*)
- Brevibacterium immariophilum*
- 5 *Brevibacterium lactofermentum*
(*Corynebacterium glutamicum*)
- Brevibacterium roseum*
- Brevibacterium saccharolyticum*
- Brevibacterium thiogenitalis*
- 10 *Corynebacterium thermoaminogenes*
- Specifically, the following strains can be exemplified.
- 15 *Corynebacterium acetoacidophilum* ATCC 13870
- Corynebacterium acetoglutamicum* ATCC 15806
- Corynebacterium callunae* ATCC 15991
- Corynebacterium glutamicum* ATCC 13020
- Corynebacterium lilium* (*Corynebacterium glutamicum*) ATCC 15990
- 20 *Corynebacterium melassecola* ATCC 17965
- Brevibacterium divaricatum*
(*Corynebacterium glutamicum*) ATCC 14020
- Brevibacterium flavum* (*Corynebacterium glutamicum*) ATCC 14067
- 25 *Brevibacterium immariophilum* ATCC 14068
- Brevibacterium lactofermentum*
(*Corynebacterium glutamicum*) ATCC 13869

Brevibacterium roseum ATCC 13825

Brevibacterium saccharolyticum ATCC 14066

Brevibacterium thiogenitalis ATCC 19240

Corynebacterium thermoaminogenes AJ12340

(FERM BP-1539)

PBP referred to in the present invention is a membrane protein that exists in the cellular surface layers of the above coryneform bacteria, and if it contacts with penicillin, it binds thereto with a covalent bond. PBP can be detected by, for example, adding labeled penicillin to a membrane fraction of coryneform bacteria to allow a reaction, subjecting a surface active agent-soluble fraction to electrophoresis on polyacrylamide gel, and visualizing the label (penicillin binding test). As shown in the examples mentioned below, PBPs of *Brevibacterium lactofermentum* are detected as three bands at molecular weights of about 110 kDa, 100 kDa and 60 kDa in SDS polyacrylamide gel electrophoresis (SDS-PAGE) in a state that they bind to penicillin G, and they were designated as PBP1, PBP2 and PBP3.

When affinity between these PBPs and mecillinam, which is a derivative of penicillin G, was investigated, it was found that mecillinam selectively binds to PBP3. Further, it was found that, when *Brevibacterium lactofermentum* was cultured under a condition that

biotin was present in a significant amount, L-glutamic acid was produced in the presence of a certain concentration of mecillinam. These facts suggested that L-glutamic acid production could be induced in the presence of a significant amount of biotin by inhibiting the function of PBPs, at least PBP3. Therefore, a coryneform bacterium in which PBP does not normally function should come to be able to induce L-glutamic acid production without addition of a biotin activity suppressor even in the presence of a significant amount of biotin. Moreover, there is possibility that such a coryneform bacterium in which PBP does not normally function should have improved L-glutamic acid producing ability. Furthermore, a novel finding concerning the L-glutamic acid production of coryneform bacteria should be obtained by manipulating a PBP gene, and it can be utilized for development from an aspect that have not been known yet.

In the present invention, the expression "PBP does not normally function" means a state that the L-glutamic acid production is induced in the presence of a significant amount of biotin. It may be a state that PBP is not produced because of inhibition of transcription or translation of a PBP gene, or a state that the function of PBP is reduced or eliminated because of a mutation occurring in the produced PBP.

<2> Coryneform bacterium in which PBP does not function normally

The coryneform bacterium used for the method for producing of L-glutamic acid according to the present invention is a coryneform bacterium in which PBP does not function normally. In a preferred embodiment, the coryneform bacterium used in the aforementioned method is a bacterium in which PBP functions normally under the first culture condition and does not function normally under the second culture condition. Such a coryneform bacterium can proliferate under the first culture condition, and can produce L-glutamic acid under the second culture condition in the presence of a significant amount of biotin. As PBP, PBP3 is preferred.

As the aforementioned culture condition, there can be mentioned temperature of culture, osmotic pressure of medium, pH, components of medium and so forth. Examples of the components of medium include an inducer such as IPTG (isopropyl- β -D-thiogalactopyranoside) and acetic acid, and a suppressor such as glucose. The culture temperature will be explained as an example of the culture condition in the description hereinafter. However, concerning other culture conditions, the term "temperature" in the following description can be replaced with a term indicating another condition.

As an example of the coryneform bacterium in which PBP does not function normally, there can be mentioned a

mutant strain in which a mutation is introduced into a gene coding for PBP (PBP gene) so that PBP that functions normally should not be expressed. The aforementioned mutation may be a mutation that inhibits transcription or translation of the PBP gene, or a mutation that produces PBP that does not function normally.

Since a mutation that causes complete deficiency of PBP should be fatal to the bacteria, the aforementioned mutant strain can be obtained as a conditional mutant strain such as a temperature sensitive mutant strain. Such a mutant strain can be obtained by, for example, treating a coryneform bacterium by ultraviolet irradiation or with a chemical agent to obtain mutant strains that can proliferate at the first temperature (for example, low temperature) but cannot proliferate at the second temperature (for example, high temperature), and selecting, from the obtained mutant strains, a mutant strain that can proliferate at the first temperature and produces L-glutamic acid in the presence of a significant amount of biotin when it is cultured at the second temperature. As a mutant strain that represents such a characteristic, a DTSR protein deficient strain (International Patent Publication WO95/23224) or an α -KGDH deficient strain (International Patent Publication WO95/34672) may be selected. However, it can be confirmed if a candidate

strain is a mutant strain having a mutation concerning PBP by performing the aforementioned penicillin binding test for the cells cultured at the second temperature.

5 If such a mutant strain is once obtained, a PBP gene of the coryneform bacterium can be cloned by using the mutant strain as a host. That is, a DNA fragment containing a PBP gene can be obtained by transforming the mutant strain in which PBP does not function normally with a plasmid containing chromosomal DNA
10 derived from coryneform bacteria, selecting a transformant strain in which PBP functions normally, and collecting the plasmid.

Techniques used for usual gene recombination such as those for digestion and ligation of DNA,
15 transformation, extraction of recombinant DNA from transformants, colony hybridization and so forth are described in references well known to those skilled in the art, for example, J. Sambrook, E.F. Fritsch, and T. Maniatis, Molecular Cloning, Cold Spring Harbor Laboratory Press (1989) and so forth.
20

A chromosomal DNA library can be produced, for example, as follows. First, chromosomal DNA is prepared by the method of Miura et al. (H. Saito, and K. Miura, Biochem. Biophys. Acta, 72, 619 (1963)) or the like.
25 Then, the chromosomal DNA is partially digested with a suitable restriction enzyme to obtain a mixture of various fragments. If the degree of the digestion is

controlled by adjusting digestion reaction time or the like, restriction enzymes of a wide range can be used. For example, the chromosomal DNA is digested by allowing *Sau3AI* to act on it at a temperature of 30°C or higher, preferably 37°C or higher, for various periods of time (1 minute to 2 hours) at an enzyme concentration of 1-10 units/ml.

Subsequently, the digested chromosomal DNA fragments are ligated to vector DNA autonomously replicable within *Escherichia coli* cells to produce recombinant DNA. More specifically, a restriction enzyme producing the same end nucleotide sequence as the restriction enzyme used for the digestion of the chromosomal DNA, *Sau3AI*, for example, *BamHI*, is allowed to act on the vector DNA at a temperature of 30°C or higher for 1 hour or more, preferably 1-3 hours, at an enzyme concentration of 1-100 units/ml to fully digest the vector and cleave it. Then, the mixture of the chromosomal DNA fragments and the cleaved vector DNA obtained as described above are mixed, and a DNA ligase, preferably T4 DNA ligase, is allowed to act on the mixture at a temperature of 4-16°C for 1 hour or more, preferably 6-24 hours, at an enzyme concentration of 1-100 units/ml to obtain recombinant DNA.

The vector autonomously replicable in *Escherichia coli* cells is preferably a plasmid vector autonomously replicable in the host cell, and examples thereof

include pUC19, pUC18, pBR322, pHSG299, pHSG399, pHSG398, RSF1010 and so forth.

Moreover, if a DNA fragment having an ability to make a plasmid autonomously replicable in coryneform bacteria (it can be prepared from, for example, pAM330 (refer to Japanese Patent Laid-open (Kokai) No. 58-67699), pHM1519 (refer to Japanese Patent Laid-open No. 58-77895), pCG1 (refer to Japanese Patent Laid-open No. 57-134500), pCG2 (refer to Japanese Patent Laid-open No. 58-35197), pCG4 (refer to Japanese Patent Laid-open No. 57-183799), pCG11 (refer to Japanese Patent Laid-open No. 57-183799) and so forth) is inserted into the aforementioned vectors, they can be used as a so-called shuttle vector autonomously replicable in both of *Escherichia coli* and coryneform bacteria.

Examples of such a shuttle vector include those mentioned below. There are also indicated microorganisms that harbor each vector, and accession numbers thereof at international depositories are shown in the parentheses, respectively.

pAJ655: *Escherichia coli* AJ11882 (FERM BP-136)

Corynebacterium glutamicum SR8201 (ATCC 39135)

pAJ1844: *Escherichia coli* AJ11883 (FERM BP-137)

Corynebacterium glutamicum SR8202 (ATCC39136)

pAJ611: *Escherichia coli* AJ11884 (FERM BP-138)

pAJ3148: *Corynebacterium glutamicum* SR8203 (ATCC 39137)

pAJ440: *Bacillus subtilis* AJ11901 (FERM BP-140)

By using the obtained recombinant DNA, for example, *Escherichia coli* K-12 strain is transformed to prepare a chromosomal DNA library. This transformation can be performed by the method of D.M. Morrison (*Methods in Enzymology*, 68, 326, 1979), the method comprising treatment of recipient cells with calcium chloride to increase their permeability for DNA (M. Mandel, and A. Higa, *J. Mol., Biol.*, 53, 159 (1970)) or the like.

Then, a mutant strain of a coryneform bacterium in which PBP does not function normally is transformed with the obtained chromosomal DNA library. As the method for transformation of coryneform bacteria, there is the aforementioned method utilizing a treatment of cells with calcium chloride or a method comprising allowing cells at a particular growth phase where they can take up DNA to take up it (reported for *Bacillus subtilis* by C.H. Duncan et al.). In addition to these, also employable is a method of making DNA-recipient cells into protoplasts or spheroplasts which can easily take up recombinant DNA, followed by allowing introduction of the recombinant DNA into the cells, which is known to be applicable to *Bacillus subtilis*, actinomycetes and yeasts (S. Chang, et al., *Molec. Gen. Genet.*, 168, 111 (1979); Bibb, et al., *Nature*, 274, 398 (1978); A. Hinnen, et al., *Proc. Natl. Sci. USA*, 75, 1929 (1978)). Other

than those, a method for transformation of coryneform bacteria is also disclosed in Japanese Patent Laid-open No. 2-207791).

5 A transformant strain introduced with a PBP gene
can be obtained by plating the transformed mutant strain
under a condition where a mutant strain (host) that is
not transformed cannot grow, and selecting a strain that
has formed a colony. A DNA fragment containing a PBP
gene can be obtained from the obtained transformant by
10 isolating the recombinant DNA, for example, by the
method of P. Guerry, et al. (*J. Bacteriol.*, 116, 1064
(1973)), the method of D.B. Clewell (*J. Bacteriol.*, 110,
667 (1972)) or the like. A coryneform bacterium
transformed with recombinant DNA containing a PBP gene
15 can also possibly be obtained by hybridization using a
gene coding for a known PBP of a microorganism, for
example, PBP of *Escherichia coli*, or an oligonucleotide
produced based on the nucleotide sequence thereof.

Besides the mutagenesis treatment, a coryneform
20 bacterium in which PBP does not function normally can be
created by using a PBP gene obtained as described above.
A PBP gene on chromosome can be disrupted by
transforming a coryneform bacterium with DNA containing
a PBP gene modified with internal deletion so as not to
25 produce PBP functioning normally (deletion type PBP
gene), and allowing recombination between the deletion
type PBP gene and the PBP gene on the chromosome. Such

gene destruction by homologous recombination has already been established, and there are methods utilizing a linear DNA, a plasmid that contains a temperature sensitive replication control region and so forth. In the present invention, the method utilizing a plasmid that contains a temperature sensitive replication control region is preferred.

A PBP gene on host chromosome can be replaced with the deletion type PBP gene as follows. That is, recombinant DNA is first prepared by inserting a temperature sensitive replication control region, mutant PBP gene and marker gene for resistance to a drug such as chloramphenicol, with which recombinant DNA a coryneform bacterium is transformed. Further, the resultant transformant strain is cultured at a temperature at which the temperature sensitive replication control region does not function, and then the transformant strain can be cultured in a medium containing the drug to obtain a transformant strain in which the recombinant DNA is incorporated into the chromosomal DNA.

In such a strain in which recombinant DNA is incorporated into chromosomal DNA, the mutant PBP gene is recombined with the PBP gene originally present on the chromosome, and the two fusion genes of the chromosomal PBP gene and the deletion type PBP gene are inserted into the chromosome so that the other portions

of the recombinant DNA (vector segment, temperature sensitive replication control region and drug resistance marker) should be present between the two fusion genes. Therefore, the transformant expresses PBP, because the
5 normal PBP gene is dominant in this state, and it can grow.

Then, in order to leave only the deletion type PBP gene on the chromosomal DNA, one copy of the PBP gene is eliminated together with the vector segment (including
10 the temperature sensitive replication control region and the drug resistance marker) from the chromosomal DNA by recombination of the two PBP genes. In that case, the normal PBP gene is left on the chromosomal DNA, and the deletion type PBP gene is excised from the chromosomal
15 DNA, or to the contrary, the deletion type PBP gene is left on the chromosomal DNA, and the normal PBP gene is excised from the chromosome DNA. In the both cases, the excised DNA may be retained in the cell as a plasmid when the cell is cultured at a temperature at which the
20 temperature sensitive replication control region can function. Subsequently, the cell is cultured at a temperature at which the temperature sensitive replication control region cannot function. In the
25 culture, the cell cannot proliferate when the deletion type PBP gene is left on the chromosomal DNA, since the plasmid containing the normal PBP gene is dropped from the cell. On the other hand, when the normal PBP gene

is left on the chromosomal DNA, the cell can proliferate. Thus, a strain in which the PBP gene on the chromosomal DNA is disrupted and the normal PBP gene is harbored on the plasmid can be obtained by selecting a strain that
5 can proliferate at a temperature at which the temperature sensitive replication control region functions, but cannot proliferate at a temperature at which the temperature sensitive replication control region does not function.

10 When the strain with the disrupted PBP gene obtained as described above is cultured at a temperature at which the temperature sensitive replication control region functions (for example, low temperature), it ; retains the PBP gene in the cell, and when it is
15 cultured at a temperature at which the temperature sensitive replication control region does not function (for example, high temperature), it loses the PBP gene. In the following description, a temperature at which a temperature sensitive plasmid cannot replicate is
20 referred to as a high temperature. However, it is not intended to exclude possibility that the temperature is a low temperature, and if a temperature sensitive replication control region is obtained which cannot replicate at a low temperature but can replicate at a
25 high temperature, it may also be used.

A strain which is made *reca*⁻ after the PBP gene on chromosome DNA is disrupted and the normal PBP gene is

incorporated into a plasmid is preferably used as the microorganism used in the present invention, since in such a strain, incorporation of the PBP gene on the plasmid into the chromosome during culture at a low temperature is prevented and thus the drop of the gene is secured.

The temperature sensitive replication control region can be obtained by subjecting a plasmid autonomously replicable in a coryneform bacterium cell and having drug resistance to a mutagenesis treatment, transforming a coryneform bacterium with the plasmid and extracting a plasmid from a transformant that can grow at a low temperature but cannot grow at a high temperature in a medium containing the drug.

As the method for the mutagenesis of plasmid, there can be mentioned the method utilizing an in vitro treatment of plasmid with hydroxylamine (G.O. Humpherys, et al., *Molec. Gen. Genet.*, 145, 101-108 (1976) etc.).

The terms "low temperature" and "high temperature" herein used have relative concepts, and the border between the low temperature and the high temperature is not particularly limited. The "low temperature" means a temperature range wherein coryneform bacteria can at least proliferate when they are cultured. The "high temperature" means a temperature wherein coryneform bacteria themselves shall not die. The border of the low temperature and the high temperature can be

determined by cultivating a transformant harboring a temperature sensitive plasmid in a medium containing a drug at various temperatures to determine a lower limit temperature above which the transformant cannot grow.

5 Examples of the plasmid that has a temperature sensitive replication control region functioning in a coryneform bacterium cell include pHS4, pHS22 and pHS23. Plasmid pHSC4, which is obtained by ligating a DNA
10 fragment excised from pHS4 and containing a replication control region derived from a coryneform bacterium to a vector for *Escherichia coli*, pHSG398, can also be used for the present invention as a temperature sensitive
15 plasmid. pHSC4 autonomously proliferates in coryneform bacteria and *Escherichia coli*, and it imparts chloramphenicol resistance to a host. *Escherichia coli* AJ12571 harboring pHSC4 was deposited at the National
20 Institute of Bioscience and Human-Technology, the Agency of Industrial Science and Technology, the Ministry of International Trade and Industry on October 11, 1990, and received an accession number of FERM P-11763. Then,
25 it was transferred to an international deposit under the provisions of the Budapest Treaty on August 26, 1991, and received an accession number of FERM BP-3524.

 These temperature sensitive plasmids can
30 autonomously proliferate at about 10-32°C in a coryneform bacterium cell, but they cannot autonomously proliferate at about 34°C or higher.

A DNA fragment that has a temperature sensitive replication control region can be obtained by, for example, digesting the aforementioned pHSC4 with *Bam*HI and *Kpn*I.

5 Construction of the aforementioned plasmids and nucleotide sequences of the regions containing a temperature sensitive replication control region thereof are disclosed in Japanese Patent Publication (Kokoku) No. 7-108228.

10 It is also known that, in *Escherichia coli*, some of a penicillin binding protein genes form a gene cluster, and *murE* gene and PBP3 gene (*ftsI*) are located closely to each other (F. Ishino, Nippon Nokeikagaku, Kaishi, vol.63, No.11, 1755-1764 (1989)). Therefore, a
15 PBP gene may be obtained together with the *murE* gene by transforming a *murE* temperature sensitive mutant as a host, which has been already obtained for coryneform bacteria, with a plasmid containing chromosomal DNA derived from a coryneform bacterium to obtain a
20 transformant strain that has come to be able to grow at a temperature at which the host cannot grow. The inventors of the present invention successfully obtained a PBP gene based on this concept as described in the examples mentioned below.

25 Further, since the nucleotide sequences of the PBP gene and flanking regions were elucidated by the present invention, the PBP gene can readily be obtained by

preparing primers based on the sequence and performing PCR (polymerase chain reaction; refer to T.J. White, et al., *Trends Genet.*, 5, 185 (1989)) utilizing coryneform bacterium chromosomal DNA as a template.

5 The nucleotide sequence containing the PBP gene obtained in the examples mentioned later is shown as SEQ ID NO: 1 in Sequence Listing. In this nucleotide sequence, there exist three opening reading frames (ORF) (nucleotide numbers 881-2623, 2790-4454 and 4467-5345).
10 The amino acid sequences encoded by the ORFs are shown as SEQ ID NOS: 2-4.

 When an existing protein database was searched for sequences exhibiting homology with these amino acid
15 sequences, it was found that the amino acid sequence encoded by the first OFR showed homology of about 31% with the amino acid sequence encoded by the PBP3 gene (*ftsI*) of *Escherichia coli* on the amino acid level. The amino acid sequences encoded by the second and the third
20 OFRs showed homology to the amino acid sequences encoded by the murE gene and the murF gene of *Escherichia coli*, respectively. These results suggested that the first
 OFR is the PBP gene corresponding to the *ftsI* of *Escherichia coli*.

25 The PBP gene of the present invention may code for substitution, deletion, insertion, addition or inversion of one or several amino acids, so long as the activity of the encoded protein for binding to penicillin is not

degraded. The number meant by the term "several" used herein may vary depending on locations in the three-dimensional structure of proteins and kinds of amino acid residues. This is due to the fact that there are analogous amino acids among amino acids such as isoleucine and valine, and difference among such amino acids does not substantially affect the three-dimensional structure of proteins. Therefore, the encoded protein may be one having homology of 30-40% or more, preferably 55-65% or more, with respect to the entire amino acid sequence constituting the protein, and having the activity for binding to penicillin.

Such DNA encoding a protein substantially the same as a penicillin binding protein as mentioned above can be obtained by modifying the nucleotide sequence by, for example, the site-directed mutagenesis so that the amino acid residues of a specific site should include substitution, deletion, insertion, addition or inversion. Such modified DNA as mentioned above can also be obtained by an already known mutagenesis treatment. Examples of the mutagenesis treatment include in vitro treatment of DNA coding for a penicillin binding protein with hydroxylamine etc., treatment of a microorganism having DNA coding for a penicillin binding protein, for example, *Escherichia* bacteria, by ultraviolet irradiation or with a mutagenizing agent used for usual mutagenesis treatment such as N-methyl-N'-nitro-N-

nitrosoguanidine (NTG) or nitrous acid.

The substitution, deletion, insertion, addition or inversion of nucleotides described above also includes mutation (mutant or variant) that naturally occurs due to individual difference, difference in species or genera of the microorganism having a penicillin binding protein.

DNA coding for substantially the same protein as a penicillin binding protein can be obtained by expressing DNA having such a mutation as described above in an appropriate cell, and examining the penicillin binding activity of an expressed product. DNA coding for substantially the same protein as a penicillin binding protein can also be obtained by isolating DNA hybridizable with DNA having, for example, the nucleotide sequence of nucleotide numbers 881 to 2623 in SEQ ID NO: 1 in Sequence Listing under a stringent condition and coding for a protein having the penicillin binding activity from DNA coding for penicillin binding protein having mutation or from a cell harboring it. The "stringent condition" referred to herein is a condition under which a so-called specific hybrid is formed, and a non-specific hybrid is not formed. It is difficult to clearly express this condition by using numerical values. However, for example, the stringent condition includes a condition under which two of DNA having high homology, for example, two of DNA having

homology of not less than 50% are hybridized with each other, and two of DNA having homology lower than the above are not hybridized with each other. Alternatively, the stringent condition is exemplified by a condition under which two of DNA are hybridized with each other at a salt concentration corresponding to an ordinary condition of washing in Southern hybridization, i.e., 60°C, 1 x SSC, 0.1% SDS, preferably 0.1 x SSC, 0.1% SDS.

The genes hybridizable under the condition as described above includes those having a stop codon generated in the gene, and those having no activity due to mutation of the active center. However, such mutant genes can be easily removed by ligating the genes with a commercially available activity expression vector, and measuring the penicillin binding activity.

<3> Production of L-glutamic acid

L-Glutamic acid can be produced by cultivating such a coryneform bacterium as described above in which PBP does not function normally and which has L-glutamic acid producing ability in a liquid medium to produce and accumulate L-glutamic acid in the medium, and collecting the L-glutamic acid. According to the method of the present invention, L-glutamic acid can be produced in a medium containing a significant amount of biotin such as molasses without adding a biotin activity inhibitor.

When the coryneform bacterium used is a bacterium

of which PBP normally functions at the first temperature and does not normally function at the second temperature, the bacterium is cultured at the first temperature to allow it to proliferate, and then cultured with shifting
5 the temperature to the second temperature to produce L-glutamic acid.

Specifically, the temperature shifting can be attained by, for example, performing seed culture at a low temperature and performing culture in a main medium
10 (main culture) at a high temperature. The temperature may also be shifted during preculture or main culture. The step of cell proliferation and the step of drop of plasmid are not clearly distinguished, and the step of drop of plasmid is accompanied with proliferation of
15 cells.

As for the timing of the temperature shift, the period for the culture at a low temperature can readily be decided by carrying out preliminarily experiments with various periods of culture until the temperature
20 shift. In general, the culture can be continued until a desired cell density is attained in the logarithmic growth phase, and then the temperature can be shifted to a level at which the plasmid cannot replicate.

The medium used for the culture is not
25 particularly limited, and there can be used a usual medium containing a carbon source, nitrogen source, and inorganic ions as well as organic trace nutrients as

required. In the present invention, in particular, a medium containing a significant amount of biotin may be used.

As the carbon source, there can be used
5 saccharides such as glucose, lactose, galactose, fructose and hydrolysate of starch, alcohols such as ethanol and inositol, organic acids such as acetic acid, fumaric acid, citric acid and succinic acid and so forth.

As the nitrogen source, inorganic ammonium salts
10 such as ammonium sulfate, ammonium chloride and ammonium phosphate, organic nitrogen such as soybean hydrolysate, ammonia gas, aqueous ammonia and so forth can be used.

As the inorganic ions or sources thereof, a small
amount of potassium phosphate, magnesium sulfate, iron
15 ions, manganese ions and so forth may be added. As a trace amount organic nutrient, it is desirable to add a suitable amount of required substances such as vitamin B₁ and yeast extract and so forth as required.

The culture is preferably performed for 16 to 72
20 hours under an aerobic condition, and the culture temperature is controlled to be 20 to 45°C, and pH to be 5-8.5 during the culture. For adjusting pH, inorganic or organic acidic or alkaline substances, ammonia gas and so forth can be used.

Collection of L-glutamic acid from the culture can
25 usually be carried out by using a combination of known techniques such as techniques using ion exchange resins,

precipitation methods and so forth.

Brief Description of the Drawing

5 Fig. 1 is a graph showing inhibition by mecillinam for binding of PBP3 and penicillin G. The arrow indicates the minimum inhibitory concentration.

Best Mode for Carrying out the Invention

10 Hereafter, examples of the present invention will be explained.

Example 1: Detection of PBP of coryneform bacteria

15 Detection of PBP of coryneform bacteria was performed based on the aforementioned method of Spratt, et al., and specifically as follows.

<1> Preparation of membrane fraction

20 PBP is considered to be a membrane protein. A membrane fraction of a coryneform bacterium was prepared as follows. A wild strain of coryneform bacteria, *Brevibacterium lactofermentum* ATCC 13869 strain, was inoculated to 20 ml of A medium (containing 10 g of polypeptone, 5 g of yeast extract, 5 g of NaCl and 5 g of glucose in 1 L of water), cultured at 30°C with shaking, and harvested when the absorption at 660 nm
25 reached about 1.0. The cells were washed in 50 mM

sodium phosphate buffer, pH 7.0. Then, the buffer was added with glass beads and sonicated to disrupt the cells. After the disruption debris was removed by centrifugation, the buffer was subjected to

5 ultracentrifugation at 100,000 x g for 30 minutes to collect a membrane fraction. The obtained fraction was washed with the same buffer, and the fraction finally suspended in 500 μ l of the same buffer was used as the membrane fraction. Protein concentration of this

10 membrane fraction was determined by using a protein quantification kit (produced by PIERCE, Micro BCA Protein assay kit), and found to be 4 mg/ml.

<2> Penicillin binding reaction

15 A volume of 30 μ l of the prepared membrane fraction was added with 3 μ l of 14 C-penicillin G (produced by Amersham) and allowed to react at 30°C for 10 minutes. Then, it was added with 2 μ l of 15% sarcosyl (sodium N-lauroylsarcosine) and 45 mg/ml of

20 penicillin G, and left for 20 minutes at room temperature. Then, the fraction was centrifuged at 13,000 rpm for 30 minutes at 20°C to obtain a soluble fraction. A sample of this fraction was subjected to SDS-PAGE using gel containing 10% of polyacrylamide, and

25 the gel was fixed, dried and analyzed with an image analyzer BAS2000 produced by Fuji Photo Film Co., Ltd. As a result, three bands were detected at 110 kDa, 100

kDa and 60 kDa, and designated as PBP1, PBP2 and PBP3, respectively.

<3> Analysis using PBP binding inhibitor

5 Affinity between mecillinam, which is a derivative
of penicillin G, and PBP was investigated. The affinity
between the derivative and PBP was investigated by
adding mecillinam at various concentrations before the
aforementioned penicillin binding reaction, and
10 measuring degree of inhibition of the binding with
isotope (^{14}C) labeled penicillin G. As a result, only
PBP3 was inhibited for binding with the labeled
penicillin G by the addition of mecillinam. That is, it
was clarified that mecillinam should selectively bind to
15 PBP3 (Fig. 1).

Example 2: Glutamic acid production by coryneform
bacterium induced by addition of mecillinam

20 The *Brevibacterium lactofermentum* ATCC 13869
strain was inoculated to the aforementioned A medium,
cultured at 30°C for 2 hours with shaking, then added
with 0.01 μM to 100 μM of mecillinam, and further
cultured for 8 hours with shaking. Subsequently,
glutamic acid concentration in the medium was measured
25 by using Biotech Analyzer AS210 (produced by Asahi
Chemical Industry Co., Ltd.) (Table 1).

Table 1

Concentration of added mecillinam (μM)	Concentration of L- glutamic acid (mg/L)
0	0
0.1	0
1.0	0
10	0
100	575

Since it was only PBP3 that bound to mecillinam under the condition where L-glutamic acid production was induced by addition of mecillinam, it was demonstrated that the glutamic acid production induced by the addition of penicillin or mecillinam was caused at least by inhibition of the function of PBP3.

Example 3: Cloning of PBP gene of *Brevibacterium lactofermentum* ATCC 13869

(1) Preparation of chromosomal DNA of *Brevibacterium lactofermentum* ATCC 13869

The *Brevibacterium lactofermentum* ATCC 13869 strain was cultured overnight in 10 ml of L medium (1% of polypeptone, 0.5% of yeast extract, 0.5 g of NaCl, 0.1% of glucose, pH 7.2), and harvested. The cells were washed with 50 mM Tris-HCl, 50 mM EDTA buffer (pH 8.0), and suspended in 800 μl of the same buffer.

To the aforementioned cell suspension, 40 μl of a 50 ml/ml lysozyme solution and 20 μl of a 10 mg/ml ribonuclease solution were added, and the mixture was incubated at 37°C for 1 hour. The mixture was added

with 20 μ l of a 20% SDS solution, and incubated at 70°C for 1 hour. Then, the mixture was added with 24 μ l of a 20 mg/ml proteinase K solution, incubated at 50°C for 1 hour, further added with 24 μ l of the proteinase K solution, and incubated for 1 hour.

The cell lysate obtained as described above was added with an equal amount of phenol and stirred. The lysate was left at 4°C overnight, and then centrifuged to collect an aqueous layer. The aqueous layer was extracted with phenol/chloroform for 2 hours, and with chloroform/isoamyl alcohol for 30 minutes. The extraction was carried out by leaving the lysate after stirring for a predetermined period of time and centrifuging it to collect an aqueous layer. DNA was collected from the obtained extract by ethanol precipitation. The precipitation of DNA was dissolved in 300 μ l of TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0).

(2) Preparation of chromosomal DNA library of *Brevibacterium lactofermentum* ATCC 13869

The chromosomal DNA of the *Brevibacterium lactofermentum* ATCC 13869 obtained as described above and a high copy number vector pHSG398 of *Escherichia coli* (Takara Shuzo) were digested by with a restriction enzyme HindIII (Takara Shuzo). These two of DNA were mixed in suitable amounts and ligated by using Takara

DNA Ligation Kit ver. 2 (Takara Shuzo) to construct a chromosomal DNA library of *Brevibacterium lactofermentum* ATCC 13869.

5 (3) Selection of PBP gene clone

 A *murE* mutant strain TLK11 of *Escherichia coli* (*murE* temperature sensitive mutation, J. Bacteriol., 1972, 110:41-46) was transformed with the chromosomal DNA library of the *Brevibacterium lactofermentum* ATCC 13869 obtained as described above, and cultured at 42°C overnight on L agar medium (L medium containing 1.5% of agar) containing 20 µg/ml of chloramphenicol.

 An emerged colony was inoculated to L liquid medium, and cultured, and plasmid was collected from the obtained cells. As a result, a *Hind*III fragment of about 5.3 kb was cloned in the plasmid. This plasmid was designated as pHS GH-H.

20 (4) Determination of nucleotide sequence of cloned DNA fragment

 The aforementioned cloned fragment was subjected to the dideoxy reaction using Thermo Sequenase fluorescent labelled primer cycle sequencing kit with 7-deaza-dGTP (Amersham Pharmacia Biotech) and determined for the nucleotide sequence by using a DNA sequencer DSQ-1000L (Shimadzu). The determined nucleotide sequence is shown as SEQ ID NO: 1.

Example 4: Construction of PBP gene-disrupted strain of

Brevibacterium lactofermentum

5 A *Brevibacterium lactofermentum* strain with
disrupted PBP gene on the chromosome was created by the
homologous recombination using the temperature sensitive
plasmid disclosed in Japanese Patent Laid-open No. 5-
7491.

10 PCR was performed by using pHSGH-H as a template
and oligonucleotides having the nucleotide sequences
shown as SEQ ID NOS: 5 and 6 as primers to amplify a PBP
gene fragment. The primer shown as SEQ ID NO: 5
contained a sequence corresponding to nucleotide numbers
31-50 of the nucleotide sequence shown as SEQ ID NO: 1,
15 and the primer shown as SEQ ID NO: 6 contained a
sequence corresponding to nucleotide numbers 2991-3014
of the nucleotide sequence shown as SEQ ID NO: 1, and
each had an EcoRI recognition sequence in the 5' end
sequence. The PCR reaction was carried out by using a
20 commercially available PCR apparatus (DNA Thermal Cycler
Model PJ2000 produced by Takara Shuzo etc.), and TaqDNA
Polymerase (Takara Shuzo) according to the
manufacturer's protocol.

25 The obtained amplified fragment was treated with
EcoRI, and inserted into the EcoRI site of pHSG299
(produced by Takara Shuzo) to produce pHSGE. Separately,
the temperature sensitive plasmid for coryneform

bacteria, pHSC4, was digested with BamHI and KpnI to obtain a gene fragment containing a replication control region, and the obtained fragment was blunt-ended by using Blunting kit produced by Takara Shuzo, and
5 inserted into the XbaI site of pHSGE using a XbaI linker (produced by Takara Shuzo) to produce pHSGX. Then, pHSGX was digested with BamHI and KpnI, blunt-ended by using Blunting kit produced by Takara Shuzo and allowed to cause self-ligation by using Takara DNA Ligation Kit
10 ver. 2 (Takara Shuzo). The obtained plasmid pHSGX Δ BK had an internal deletion of the PBP gene.

By using the plasmid pHSGX Δ BK for PBP gene substitution obtained as described above, gene
substitution between a deletion type PBP gene and a PBP
15 gene on chromosomal DNA of *Brevibacterium lactofermentum* was performed by the double recombination technique. Specifically, it was attained as follows. The
Brevibacterium lactofermentum ATCC 13869 was transformed with pHSGX Δ BK by the electric pulse method (see Japanese
20 Patent Laid-open No. 2-207791). The transformant was cultured at 25°C for 6 hours in M-CM2G liquid medium with shaking and inoculated on M-CM2G medium containing 25 μ g/ml of kanamycin. A strain that formed a colony at 34°C was obtained.

25 In the obtained strain, the deletion type PBP gene was recombined with the PBP gene originally present on the chromosome, and the two fusion genes of the

chromosomal PBP gene and the deletion type PBP gene are inserted into the chromosome so that the other portions of the recombinant DNA (vector segment, temperature sensitive replication control region and drug resistance marker) should be present between the two fusion genes. Therefore, the transformant strain could grow at a high temperature because the normal PBP gene was dominant in this state.

Then, the transformant strain was cultured at 25°C, and a strain in which the PBP gene on the chromosome was replaced with the deletion type gene was selected from the strains that could grow at 25°C but could not grow at 34°C, and designated as $\Delta P3/p3$ strain. In the $\Delta P3/p3$ strain, the deletion type PBP gene was left on the chromosomal DNA, and a plasmid containing a normal PBP gene was present in the cell. It was confirmed if the PBP gene on the chromosome was replaced with the deletion type by determining the nucleotide sequence of the ligation region left behind the deleted region.

Industrial Applicability

According to the present invention, a gene coding for a penicillin binding protein (PBP gene) of a coryneform bacterium is provided. By using a coryneform bacterium of which PBP gene on the chromosome was disrupted with the gene, L-glutamic acid can be produced

in the presence of a significant amount of biotin
without adding a biotin activity suppressor.

005000.96522900

What is claimed is:

1. A method for producing L-glutamic acid, comprising the steps of cultivating a coryneform bacterium in a liquid medium to produce and accumulate L-glutamic acid in the medium, and collecting the L-glutamic acid, wherein penicillin binding protein (PBP) does not normally function in said bacterium and said bacterium has the ability to produce L-glutamic acid.
2. The method according to claim 1, wherein the coryneform bacterium is a bacterium in which penicillin binding protein functions normally at the first temperature and does not function normally at the second temperature, comprising the steps of cultivating the bacterium at the first temperature to proliferate the bacterium, and cultivating the bacterium at the second temperature to produce L-glutamic acid.
3. The method according to claim 2, wherein the coryneform bacterium is a bacterium which harbors a plasmid comprising a gene coding for a penicillin binding protein (PBP gene) and a temperature sensitive replication control region, and in which the PBP gene on chromosome does not function, and the plasmid can replicate at the first temperature, and cannot replicate at the second temperature.

4. The method according to claim 2, wherein the penicillin binding protein produced by the coryneform bacterium has a temperature sensitive mutation.

5

5. The method according to any one of claims 1-4, wherein the penicillin binding protein shows a molecular weight of about 60,000 in SDS-polyacrylamide gel electrophoresis, when the penicillin binding protein binds to penicillin G.

10

6. The method according to any one of claims 1-4, wherein the penicillin binding protein has the amino acid sequence shown in SEQ ID NO: 2 in Sequence .

15

7. The method according to claim 3, wherein the PBP gene has a nucleotide sequence comprising at least the sequence of the nucleotide numbers 881 to 2623 of SEQ ID NO: 1 in Sequence Listing.

20

8. DNA which codes for a protein defined in the following (A) or (B):

(A) a protein which has the amino acid sequence of SEQ ID NO: 2 in Sequence Listing;

25

(B) a protein which has an amino acid sequence of SEQ ID NO: 2 in Sequence Listing including substitution, deletion, insertion, addition or inversion of one or

several amino acids, and an activity for binding to penicillin.

9. The DNA according to claim 7, which is DNA
5 defined in the following (a) or (b):

(a) DNA which comprises at least the nucleotide
sequence of the nucleotide numbers 881 to 2623 of SEQ ID
NO: 1 in Sequence Listing;

- (b) DNA which is hybridizable with a nucleotide
10 sequence comprising at least the sequence of the
nucleotide numbers 881 to 2623 of SEQ ID NO: 1 in
Sequence Listing under a stringent condition, and codes
for a protein having an activity for binding to
15 penicillin.

Abstract

L-glutamic acid is produced by cultivating a coryneform bacterium having L-glutamic acid producing ability in which the PBP gene on the chromosomal DNA is disrupted and the normal PBP gene is harbored on the plasmid comprising a temperature sensitive replication control region in a liquid medium at a temperature at which the temperature sensitive replication control region does not function, and then cultivating the bacterium at a temperature at which the temperature sensitive replication control region functions normally to produce L-glutamic acid.

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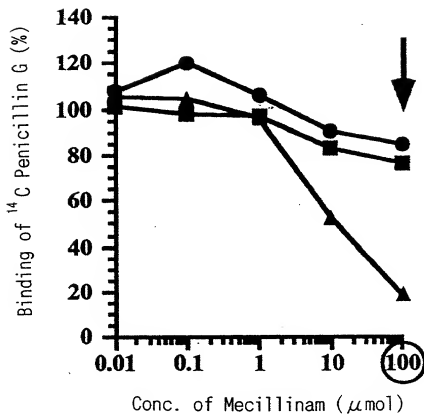


Fig. 1

Declaration, Power Of Attorney and Petition

Page 1 of 3

WE (I), the undersigned inventor(s), hereby declare(s) that:

My residence, post office address and citizenship are as stated below next to my name,

We (I) believe that we are (I am) the original, first, and joint (sole) inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A GENE CODING FOR PENICILLIN BINDING PROTEIN AND A METHOD FOR PRODUCING

L-GLUTAMIC ACID

the specification of which

☒ is attached hereto.

☐ was filed on _____ as

Application Serial No. _____

and amended on _____.

☒ was filed as PCT international application

Number PCT/JP 99/01084

on March 5, 1999

and was amended under PCT Article 19

on _____ (if applicable).

We (I) hereby state that we (I) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

We (I) acknowledge the duty to disclose information known to be material to the patentability of this application as defined in Section 1.56 of Title 37 Code of Federal Regulations.

We (I) hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed. Prior Foreign Application(s)

Application No.	Country	Day/Month/Year	Priority Claimed
10-55608	Japan	06/03/1998	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No

We (I) hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application Number)

(Filing Date)

(Application Number)

(Filing Date)

We (I) hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application Serial No.

Filing Date

Status (pending, patented,
abandoned)

And we (I) hereby appoint: Norman F. Oblon, Registration Number 24,618; Marvin J. Spivak, Registration Number 24,913; C. Irvin McClelland, Registration Number 21,124; Gregory J. Maier, Registration Number 25,599; Arthur I. Neustadt, Registration Number 24,854; Richard D. Kelly, Registration Number 27,757; James D. Hamilton, Registration Number 28,421; Eckhard H. Kuesters, Registration Number 28,870; Robert T. Pous, Registration Number 29,099; Charles L. Gholz, Registration Number 26,395; Vincent J. Sunderdick, Registration Number 29,004; William E. Beaumont, Registration Number 30,996; Steven B. Kelber, Registration Number 30,073; Robert F. Gnuse, Registration Number 27,295; Jean-Paul Lavalleye, Registration Number 31,451; Timothy R. Schwartz, Registration Number 32,171; Stephen G. Baxter, Registration Number 32,884; Martin M. Zolnick, Registration Number 35,745; Robert W. Hahl, Registration Number 33,893; Richard L. Treanor, Registration Number 36,379; Steven P. Weihrouh, Registration Number 32,829; John T. Goolkasian, Registration Number 26,142; Marc R. Labgold, Registration Number 34,651; William J. Healey, Registration Number 36,160; and Richard L. Chinn, Registration Number 34,305; our (my) attorneys, with full powers of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith; and we (I) hereby request that all correspondence regarding this application be sent to the firm of OBLON, SPIVAK, MCCLELLAND, MAIER & NEUSTADT, P.C., whose Post Office Address is: Fourth Floor, 1755 Jefferson Davis Highway, Arlington, Virginia 22202.

We (I) declare that all statements made herein of our (my) own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Masaaki WACHI

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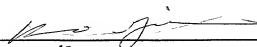
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August 18, 2000
Date

2-00
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Date

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Date

NAME OF FOURTH JOINT INVENTOR

Signature of Inventor

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Signature of Inventor

Date

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SEQUENCE LISTING

<110> WACHI, Masaaki
NAGAI, Kazuo

<120> A Gene Coding for Penicillin Binding Protein
and a Method for Producing L-Glutamic Acid

<130> 0P843-PCT

<141> 1999-03-05

<150> JP 10-55608

<151> 1998-03-06

<160> 6

<170> PatentIn Ver. 2.0

<210> 1

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 $\langle 222 \rangle$ (4467).. (5345)

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<div style="text-align:center;">230</div>																	<div style="text-align:center;">235</div>						<div style="text-align:center;">240</div>						
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<div style="text-align:center;">245</div>																	<div style="text-align:center;">255</div>						<div style="text-align:center;">260</div>						
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tt																		5347											
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Leu Gly Trp Val Gln Val Val Trp Gly Pro Glu Leu Ser Leu Asn Ala																													
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Ser Glu Gln Arg Thr Arg Val Tyr Val Asp Pro Ala Arg Arg Gly Thr																													
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Ile Val Asp Arg Glu Gly Asn Gln Met Ala Tyr Thr Met Gln Ala Arg																													
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Ser Leu Thr Val Ser Pro Asn Ile Met Arg Glu Glu Leu Lys Thr Gly																													
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Thr Asp Leu Ala Leu Arg Leu Ala Ala Glu Glu Thr Asp Pro Glu Asn																													
<div style="text-align:center;">85 90 95</div>																													
Val Ala Ser Tyr Val Thr Ile Glu Glu Gly Asn Ala Tyr Val Phe Ala																													
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Ser Glu Glu Gln Arg Glu Thr Ile Leu Ser Asp Lys Val Glu Glu Arg																													
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Ile Gln Ser Ile Ala Asp Arg Ile Pro Glu Ile Ile Lys Ser His Asp
 130 135 140
 Gln Asp Val Thr Gly Ile Ser Ser Glu Glu Ile Leu Asp Lys Leu Asn
 145 150 155 160
 Ala Asp Ser Gln Tyr Glu Val Leu Val Arg Asn Val Asp Pro Asp Val
 165 170 175
 Ala Ser Glu Ile Thr Asp Glu Met Pro Ser Val Ala Ala Asp His Gln
 180 185 190
 Asp Ile Arg Gln Tyr Pro Asn Gly Ala Ile Gly Glu Asn Ile Ile Gly
 195 200 205
 Arg Ile Ser Met Asp Gly Glu Gly Gln Phe Gly Phe Glu Ala Ser Asn
 210 215 220
 Asp Ser Leu Leu Ala Gly Asn Asn Gly Arg Ser Thr Gln Asp Met Ser
 225 230 235 240
 Ile Leu Gly Gln Ala Ile Pro Gly Thr Leu Arg Asp Gln Ile Pro Ala
 245 250 255
 Ile Asp Gly Ala Ser Val Glu Leu Thr Val Asp Leu Asp Leu Gln Thr
 260 265 270
 Tyr Val Gln Gln Ala Leu Glu Gln Ala Lys Ala Asn Ser Gly Ala Glu
 275 280 285
 Asn Ala Ser Ala Val Val Leu Asp Ala Glu Thr Ala Glu Val Leu Ala
 290 295 300
 Met Ala Asn Thr Asp Thr Ile Asn Pro Asn Glu Asp Thr Gly Lys Gln
 305 310 315 320
 Ile Glu Gln Gly Lys Ser Phe Asp Asn Pro Ser Val Thr His Pro Phe
 325 330 335
 Glu Pro Gly Ser Val Ala Lys Val Ile Thr Ala Ala Gly Val Ile Gln
 340 345 350
 Asp Gly Leu Thr Thr Pro Asp Glu Val Leu Gln Val Pro Gly Ser Ile
 355 360 365
 Glu Met Ala Gly Val Ser Val Gly Asp Ala Trp Asp His Gly Val Val
 370 375 380
 Pro Tyr Thr Thr Ala Gly Ile Phe Gly Lys Ser Ser Asn Val Gly Thr
 385 390 395 400
 Leu Met Leu Ala His Gly Leu Gly Glu Asp Lys Phe Ala Asp Tyr Leu
 405 410 415
 Glu Arg Phe Gly Val Gly Gln Ser Thr Gly Ile Glu Leu Pro Ser Glu
 420 425 430

130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430

Gly Ala Gln Phe Ala Gly Thr Asp Asn Ala Ala Lys Ala Val Ala Ile
100 105 110

Leu	Thr	Asp	Ala	Ala	Gly	Leu	Glu	Val	Leu	Asn	Glu	Ala	Gly	Glu	Thr
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Arg	Pro	Ile	Ile	Val	Val	Asp	Asp	Val	Arg	Ala	Val	Leu	Gly	Ala	Ala
	130					135					140				
Ser	Ser	Ser	Ile	Tyr	Gly	Asp	Pro	Ser	Lys	Asp	Phe	Thr	Leu	Ile	Gly
	145				150					155					160
Val	Thr	Gly	Thr	Ser	Gly	Lys	Thr	Thr	Thr	Ser	Tyr	Leu	Leu	Glu	Lys
				165						170				175	
Gly	Leu	Met	Glu	Ala	Gly	His	Lys	Val	Gly	Leu	Ile	Gly	Thr	Thr	Gly
			180					185					190		
Thr	Arg	Ile	Asp	Gly	Glu	Glu	Val	Pro	Thr	Lys	Leu	Thr	Thr	Pro	Glu
		195					200					205			
Ala	Pro	Thr	Leu	Gln	Ala	Leu	Phe	Ala	Arg	Met	Arg	Asp	His	Gly	Val
						215					220				
Thr	His	Val	Val	Met	Glu	Val	Ser	Ser	His	Ala	Leu	Ser	Leu	Gly	Arg
				230						235					240
Val	Ala	Gly	Ser	His	Phe	Asp	Val	Ala	Ala	Phe	Thr	Asn	Leu	Ser	Gln
				245					250					255	
Asp	His	Leu	Asp	Phe	His	Pro	Thr	Met	Asp	Asp	Tyr	Phe	Asp	Ala	Lys
			260					265					270		
Ala	Leu	Phe	Phe	Arg	Ala	Asp	Ser	Pro	Leu	Val	Ala	Asp	Lys	Gln	Val
		275					280					285			
Val	Cys	Val	Asp	Asp	Ser	Trp	Gly	Gln	Arg	Met	Ala	Ser	Val	Ala	Ala
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Asp	Val	Gln	Thr	Val	Ser	Thr	Leu	Gly	Gln	Glu	Ala	Asp	Phe	Ser	Ala
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Thr	Asp	Ile	Asn	Val	Ser	Asp	Ser	Gly	Ala	Gln	Ser	Phe	Lys	Ile	Asn
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Ala	Pro	Ser	Asn	Gln	Ser	Tyr	Gln	Val	Glu	Leu	Ala	Leu	Pro	Gly	Ala
								345					350		
Phe	Asn	Val	Ala	Asn	Ala	Thr	Leu	Ala	Phe	Ala	Ala	Ala	Ala	Pro	Trp
		355					360					365			
Val	Leu	Met	Ala	Thr	Phe	Ala	Arg	Gly	Met	Ser	Lys	Val	Ala	Val	Pro
					375						380				
Gly	Arg	Met	Glu	Arg	Ile	Asp	Glu	Gly	Gln	Asp	Phe	Leu	Ala	Val	Val
					390					395					400
Asp	Tyr	Ala	His	Lys	Pro	Ala	Ala	Val	Ala	Ala	Val	Leu	Asp	Thr	Leu
				405					410					415	
Arg	Thr	Gln	Ile	Asp	Gly	Arg	Leu	Gly	Ser	Gly	Tyr	Arg	Cys	Trp	Trp

420 425 430
 Arg Arg Asp Ser Thr Lys Arg Gly Pro Met Gly Ser Cys Pro His Arg
 435 440 445
 Ser Gly Ser Ser Tyr Cys Thr Asp Ala Asn Leu Val Arg Val Ala Gly
 450 455 460
 Thr Ile Arg Ala Ala Val Thr Ala Gly Ala Gln Gln Gly Ala Ser Glu
 465 470 475 480
 Ser Glu Arg Pro Val Glu Val Leu Glu Ile Gly Asp Arg Ala Glu Ala
 485 490 495
 Ile Arg Val Leu Val Glu Trp Ala Gln Pro Gly Asp Gly Ile Val Val
 500 505 510
 Ala Gly Lys Gly His Glu Val Gly Gln Leu Val Ala Gly Val Thr His
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 His Phe Asp Asp Arg Glu Glu Gly Arg Ala Ala Leu Thr Glu Lys Leu
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 Phe Asp Ser Arg Ser Leu Thr Pro Gly Gly Leu Phe Leu Ala Leu Pro
 35 40 45
 Gly Ala Arg Val Asp Gly His Asp Phe Ala Ala Thr Ala Ile Glu Lys
 50 55 60
 Gly Ala Val Ala Val Leu Ala Ala Arg Glu Val Asp Val Pro Ala Ile
 65 70 75 80
 Val Val Pro Pro Val Lys Ile Gln Glu Ser Asn Ala Asp Ile Tyr Ala
 85 90 95
 His Glu Pro Asp Gly His Gly Ala Val Val Glu Ala Leu Ser Arg
 100 105 110
 Leu Ala Arg His Val Val Asp Ile Cys Val Ala Gly His Gln Leu Asn
 115 120 125
 Val Val Ala Ile Thr Gly Ser Ala Gly Lys Thr Ser Thr Lys Asp Phe

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